Physicsaholics

DPP – 1

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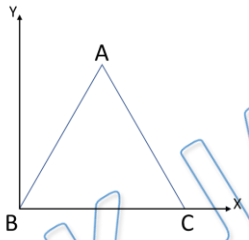
Q 1. Three particles of masses 1.0 kg, 2.0 kg and 3.0 kg are placed at the corners A,B and C respectively of an equilateral triangle ABC of edge 1m. Location of the center of mass of the system from B



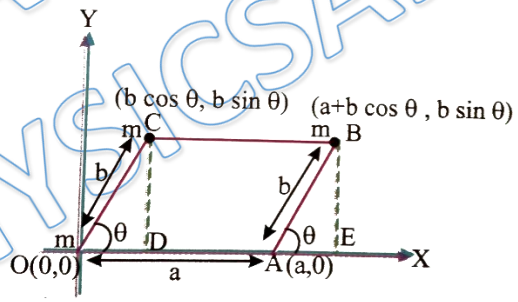
(a) $\left(\frac{7}{12}m,\ \frac{\sqrt{3}}{12}m\right)$

(b) $\left(\frac{\sqrt{3}}{12}m,\ \frac{7}{12}m\right)$

(c) $\left(\frac{\sqrt{3}}{6}m,\ \frac{7}{6}m\right)$

(d) $\left(\frac{7}{6}m,\ \frac{\sqrt{3}}{6}m\right)$

Q 2. Find position of center of mass of four identical particle system, which are at the vertices of parallelogram, as shown in figure



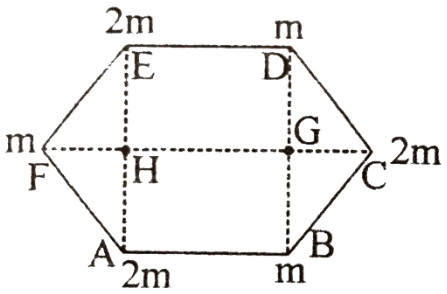
(a) $\left(\frac{a+b\cos\theta}{2}, \frac{b\sin\theta}{2}\right)$

(b) $\left(\frac{a+b\sin\theta}{2}, \frac{b\cos\theta}{2}\right)$

(c) $\left(\frac{b+a\cos\theta}{2}, \frac{a\sin\theta}{2}\right)$

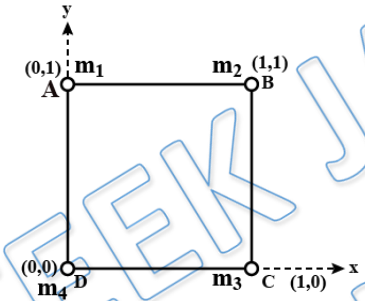
(d) $\left(\frac{b+a\sin\theta}{2}, \frac{a\cos\theta}{2}\right)$

Q 3. Find the position of center of mass for a system of particles places at the vertices of a regular hexagon of side 'a' as shown in figure (consider point F as origin, FC as x axis and hexagon is in xy plane.)



(a) $(a,\ a)$ (b) $(0,\ a)$
(c) $(a,\ 0)$ (d) $\left(\frac{a}{2},\frac{a}{2}\right)$

Q 4. Four particles of masses 1kg, 2kg, 3kg and 4kg are placed at the four vertices A, B, C and D of a square of side 1m. Find the position of center of mass of the particles



(a) $(0.5m,\ 0.5m)$ (b) $(0.3m,\ 0.3m)$
(c) $(0.3m,\ 0.5m)$ (d) $(0.5m,\ 0.3m)$

Q 5. Particles of masses m, 2m, 3m, ..., nm are placed on the same line at distances L, 2L, 3L, ..., nL from O. The distance of center of mass from O is
(a) $\left(\frac{2n+1}{4}\right)L$ (b) $\left(\frac{1}{2n+1}\right)L$
(c) n $\left(\frac{n^2+1}{2}\right)L$ (d) $\left(\frac{2n+1}{3}\right)L$

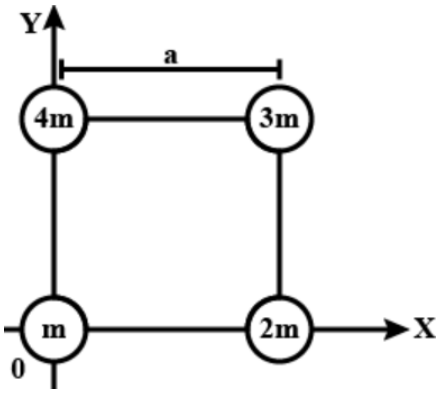
Q 6. Center of mass of 3 particle10kg, 20kg and 30kg is at (0, 0, 0,). Where should a particle of mass 40kg be placed so that the combined center of mass will be at (3,3,3)
(a) (0, 0, 0) (b) (7.5, 7.5, 7.5)
(c) (1, 2, 3) (d) (4, 4, 4)

Q 7. Two particles whose masses are 10 kg and 30kg and their position vectors are $i+\hat{j}+\hat{k}$ and $-i-\hat{j}-\hat{k}$ respectively would have the center of mass at -
(a) $-\frac{i+\hat{j}+\hat{k}}{2}$ (b) $\frac{i+\hat{j}+\hat{k}}{2}$
(c) $-\frac{i+\hat{j}+\hat{k}}{4}$ (d) $\frac{i+\hat{j}+\hat{k}}{4}$

Q 8. The center of mass of two particles lies
(a) at the midpoint on the line joining the two particles
(b) on a point outside the line joining the particles
(c) at one end of line joining the two particles

(d) on the line joining the two particles

Q 9. The four particles of masses m, 3m ,2m and 4m are placed on the vertices of a square of side a. Locate the center of mass



(a) $\left(\frac{a}{2},\frac{a}{2}\right)$ (b) $\left(\frac{7a}{10},\frac{a}{2}\right)$

(c) $\left(\frac{a}{2},\frac{7a}{10}\right)$ (d) $\left(\frac{7a}{10},\frac{7a}{10}\right)$

Q 10. Masses 8kg, 2kg, 4kg and 2kg are placed at the corners A, B, C, D respectively of a square ABCD of diagonal 80cm. The distance of center of mass from A will be

(a) 20 cm (b) 30 cm

(c) 40 cm (d) 60 cm

Q 11. A 6.00 kg object with its center of gravity at (0, 0) m, a 4.00 kg object at (0, 4.00) m, and a 5.00 kg object at (3.00, 0) m. Where should a fourth object of mass 9.00 kg be placed so that the center of gravity of the four-object arrangement will be at (0, 0)?

(a) $\left(\frac{5}{3},\frac{16}{9}\right)$ m (b) $\left(\frac{16}{9},\frac{5}{3}\right)$ m

(c) $\left(-\frac{5}{3},-\frac{16}{9}\right)$ m (d) $\left(-\frac{16}{9},-\frac{5}{3}\right)$ m

Answer Key

Q.1 a	**Q.2 a**	**Q.3 c**	**Q.4 d**	**Q.5 d**
Q.6 b	**Q.7 a**	**Q.8 d**	**Q.9 c**	**Q.10 b**
Q.11 c				

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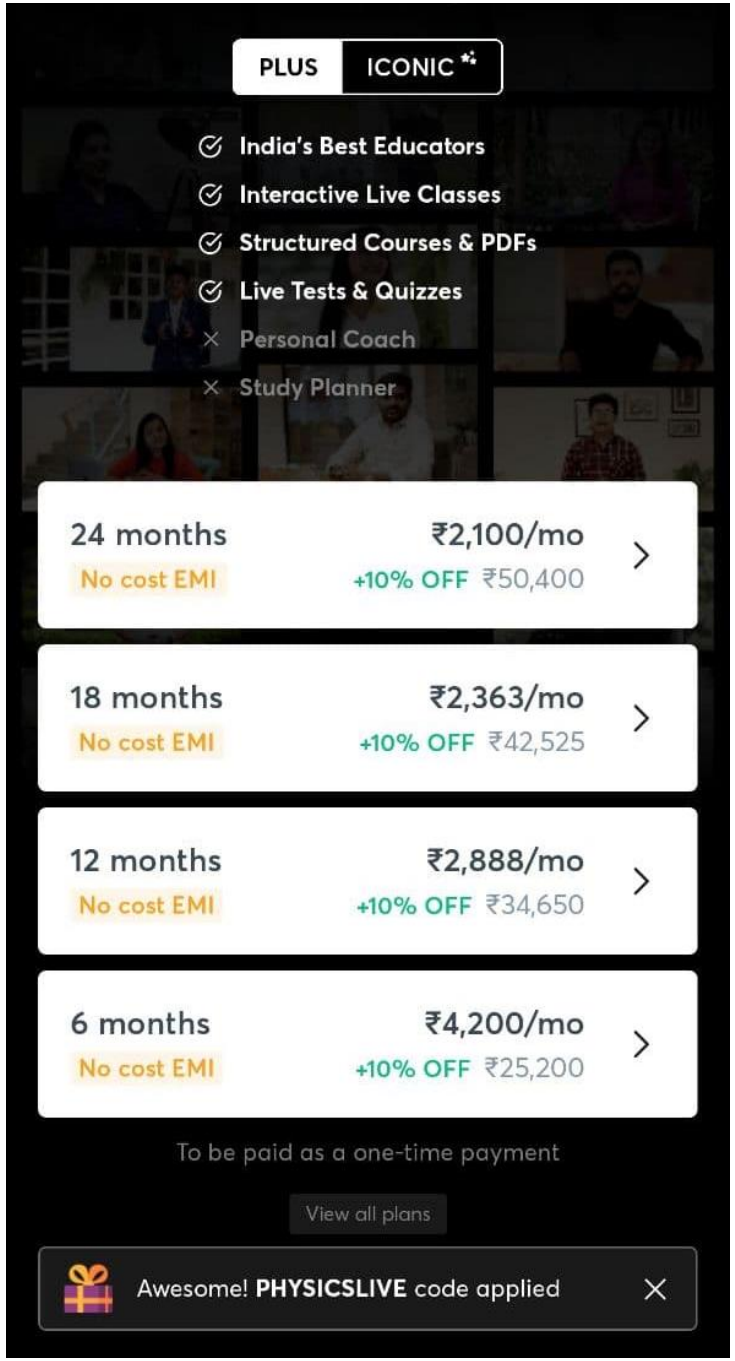


Written Solution

DPP-1 COM: Center of mass of system of particles

By Physicsaholics Team

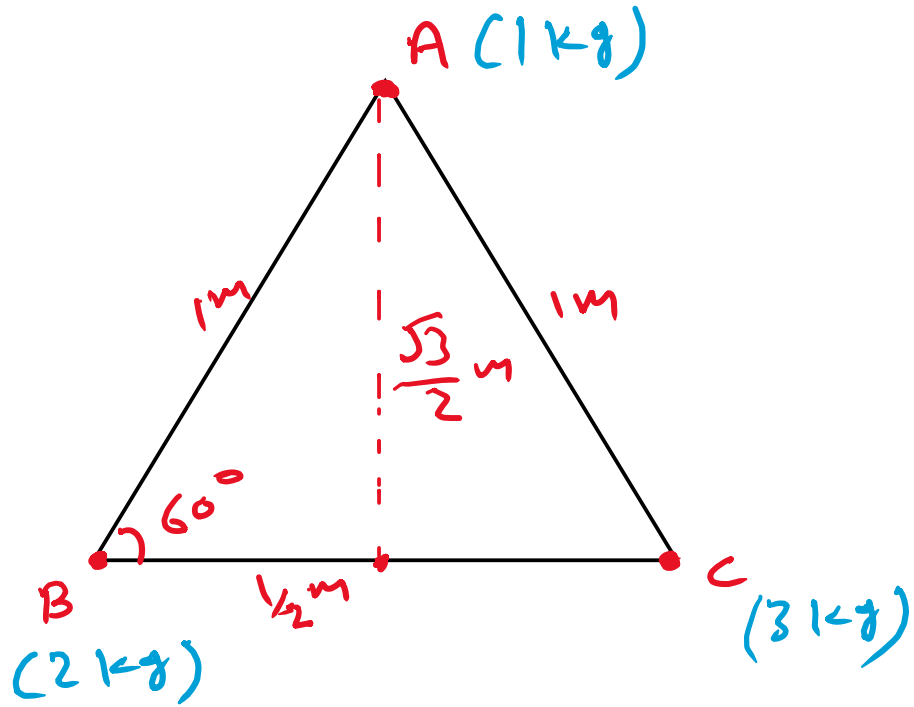
Solution: 1

From B

$$x = \frac{m_A x_A + m_B x_B + m_C x_C}{m_A + m_B + m_C}$$

$$= \frac{(1 \times 1/2) + (2 \times 0) + 3(1)}{1+2+3} = \frac{7/2}{6}$$

$$\boxed{x = \frac{7}{12}\ m}$$



From B

$$y = \frac{(1 \times \frac{\sqrt{3}}{2}) + (2 \times 0) + (3 \times 0)}{1+2+3}$$

$$y = \frac{\frac{\sqrt{3}}{2}}{6} = \frac{\sqrt{3}}{12}\ m$$

$$\boxed{y = \frac{\sqrt{3}}{12}\ m}$$

So, $\left(\frac{7}{12}, \frac{\sqrt{3}}{12}\right)$ Ans.

Ans. a

Solution: 2

$$x_{cm} = \frac{m(0) + m(b\cos\theta) + m(a + b\cos\theta) + m(a)}{4m}$$

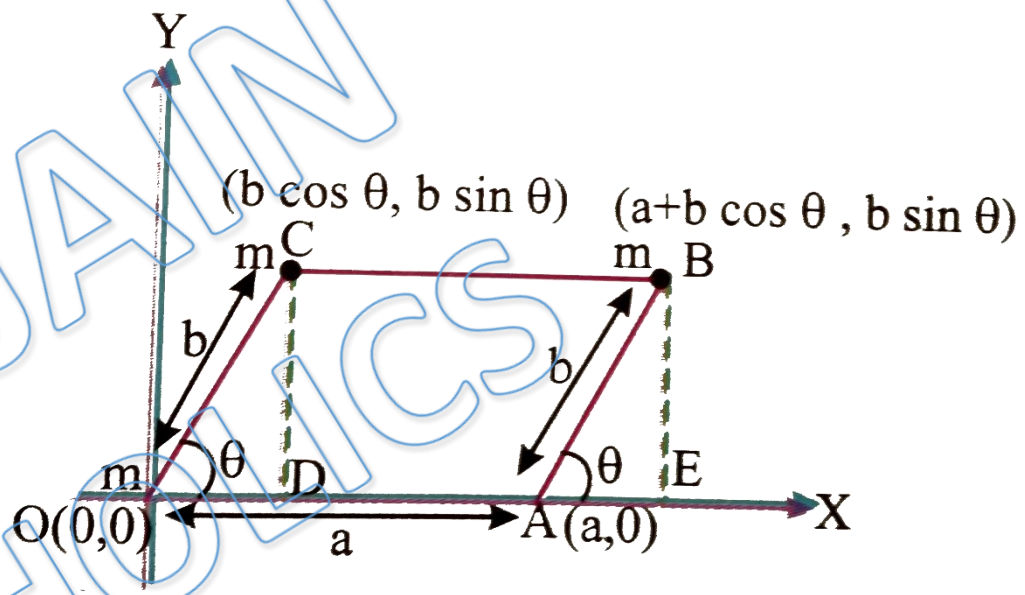
$$x_{cm} = \frac{2(a + b\cos\theta)}{4} = \frac{a + b\cos\theta}{2}$$

$$\boxed{x_{cm} = \frac{a + b\cos\theta}{2}}$$

$$y_{cm} = \frac{m(0) + m(b\sin\theta) + m(b\sin\theta) + m(0)}{4m}$$

$$y_{cm} = \frac{2b\sin\theta}{4} = \frac{b\sin\theta}{2}$$

$$\boxed{y_{cm} = \frac{b\sin\theta}{2}}$$



Ans. a

Solution: 3

$$x_{cm} = \frac{m(0) + 2\left[2m \times \left(\frac{a}{2}\right)\right] + 2\left[m \times \left(\frac{3a}{2}\right)\right] + 2m(2a)}{9m}$$

$$x_{cm} = \frac{2a + 3a + 4a}{9} = \frac{9a}{9}$$

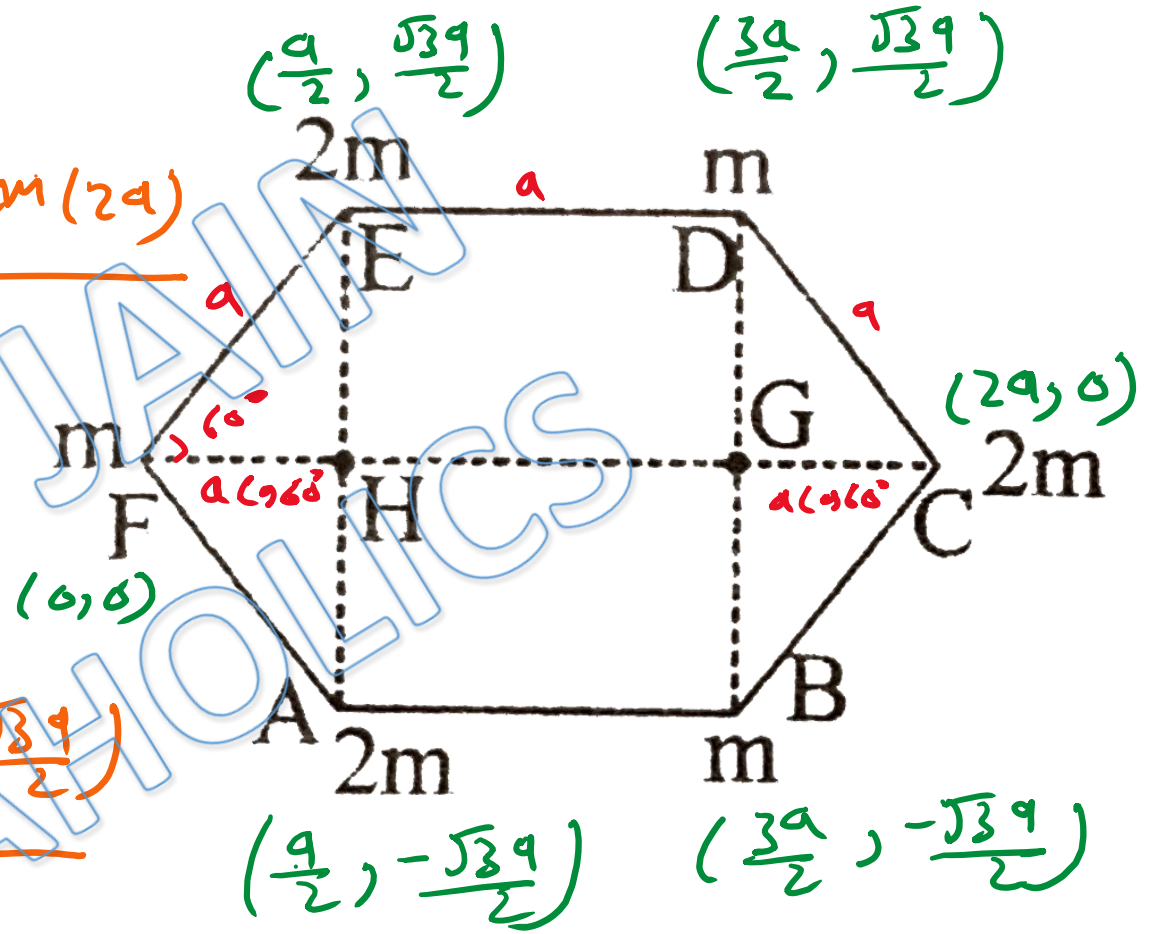
$$\boxed{x_{cm} = a}$$

$$y_{cm} = \frac{m(0) + (2m+m)\left(\frac{\sqrt{3}a}{2}\right) + (2m+m)\left(-\frac{\sqrt{3}a}{2}\right) + 2m(0)}{9m}$$

$$y_{cm} = \frac{0}{9m} = 0$$

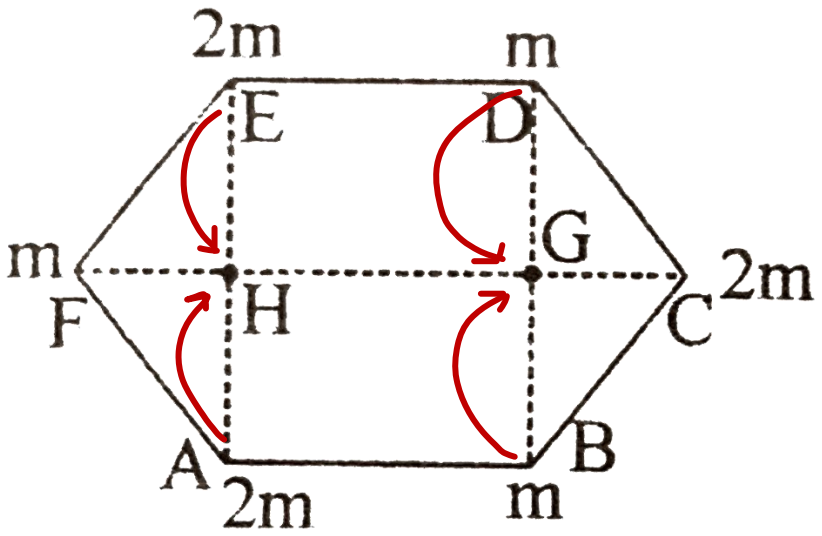
$$\boxed{y_{cm} = 0}$$

$$\therefore \boxed{(x_{cm}, y_{cm}) \equiv (a, 0)}$$

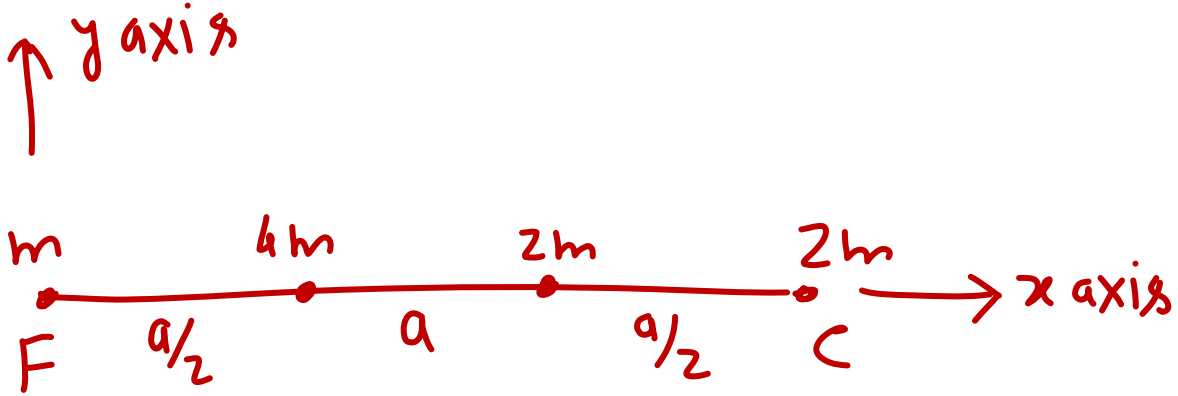


Ans. c

OR



$\Rightarrow$



$$y_{CM} = 0$$

$$x_{CM} = \frac{m\times 0 + 4m \times a/2 + 2m \times 3a/2 + 2m \times 2a}{9m} = \frac{9ma}{9m}$$

$$= a$$

Ans. c

Solution: 4

$$x_{cm} = \frac{(1+4)\times 0 + (2+3)\times 1}{1+2+3+4}$$

$$x_{cm} = \frac{5}{10} = \frac{1}{2} = 0.5$$

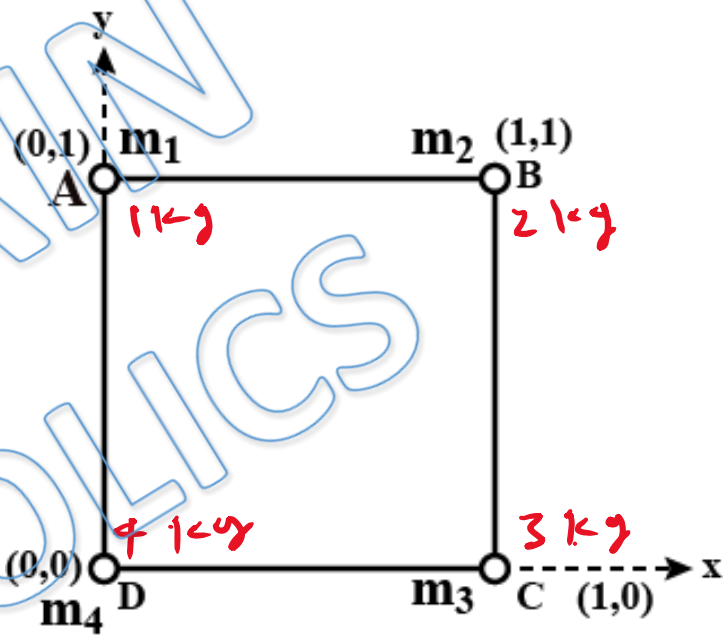
$$\boxed{x_{cm} = 0.5\ m}$$

$$y_{cm} = \frac{(1+2)\times 1 + (3+4)\times 0}{10}$$

$$y_{cm} = \frac{3}{10} = 0.3$$

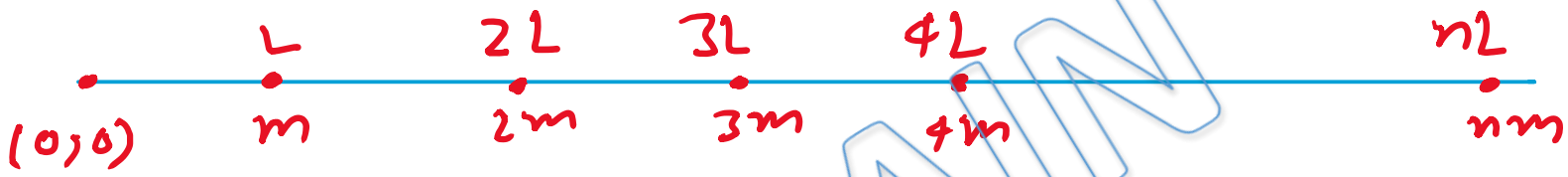
$$\boxed{y_{cm} = 0.3\ m}$$

$$\boxed{(x_{cm}, y_{cm}) \equiv (0.5\ m,\ 0.3\ m)}$$ Ans.



Ans. d

Solution: 5



$$r_{cm} = \frac{(m\,L) + (2m \times 2L) + (3m \times 3L) + \cdots + (nm \times nL)}{m + 2m + 3m + 4m + \cdots + nm}$$

$$r_{cm} = \frac{m L}{m}\left[\frac{1^2 + 2^2 + 3^2 + 4^2 + \cdots + n^2}{1 + 2 + 3 + 4 + \cdots + n}\right]$$

$$r_{cm} = L\left[\frac{\frac{n(n+1)(2n+1)}{6}}{\frac{n(n+1)}{2}}\right] = \left[\frac{2n+1}{3}\right]L$$

$$\boxed{r_{cm} = \left(\frac{2n+1}{3}\right)L} \quad \text{Ans.}$$

Ans. d

Solution: 6

com of 10kg, 20kg & 30kg

$r_{cm} = (0, 0, 0)$

$$r_{cm} = \frac{m_1 r_1 + m_2 r_2 + m_3 r_3}{m_1 + m_2 + m_3} = \frac{10 r_1 + 20 r_2 + 30 r_3}{60} \quad \text{—①}$$

com of 10kg, 20kg, 30kg & 40 kg

$$r'_{cm} = \frac{10 r_1 + 20 r_2 + 30 r_3 + 40 r_4}{100} \quad \text{—②}$$

$r'_{cm} = (3, 3, 3)$

$x'_{cm} = 3$; $x_{cm} = 0$

$$x'_{cm} = \frac{10 x_1 + 20 x_2 + 30 x_3 + 40 x_4}{100} \quad \text{—③}$$

$$x_{cm} = \frac{10 x_1 + 20 x_2 + 30 x_3}{60} \quad \text{—④}$$

$$3 = \frac{10 x_1 + 20 x_2 + 30 x_3}{100} \times 60 + \frac{40 x_4}{100}$$

$$3 = \frac{6}{10} \times 60 + 0.4 x_4$$

$$3 = 0 + 0.4 x_4$$

$$0.4 x_4 = 3$$

$$\boxed{x_4 = 7.5 \text{ m}}$$

Similarly, $y_4 = 6\text{m}$ & $z_4 = 6\text{m}$

$$\therefore \boxed{(x_4, y_4, z_4) = (7.5, 7.5, 7.5)} \text{ Ans.}$$

Ans. b

OR

$10Kg + 20Kg + 30Kg = 60Kg$

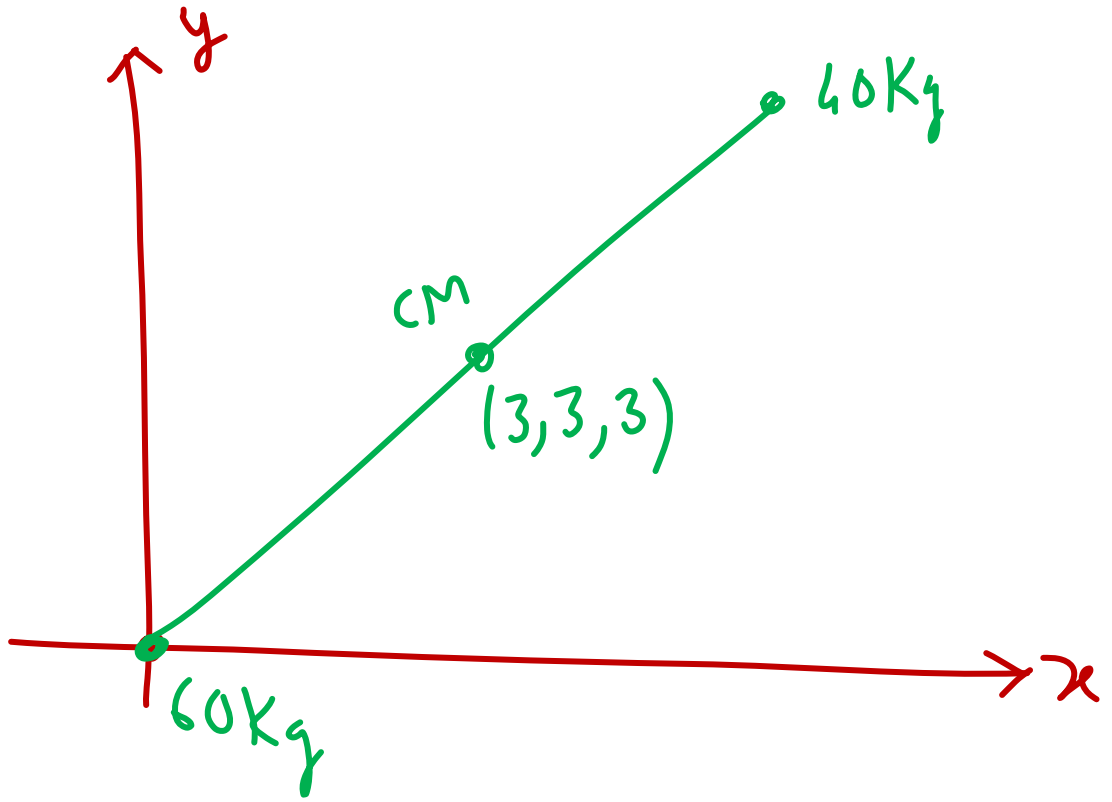
We can assume that in place of 3 particle there is only one particl of mass 60 Kg at (0,0,0)

$$\vec{r}_{CM} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1+m_2}$$

$$\Rightarrow \quad 3\hat{i}+3\hat{j}+3\hat{k} = \frac{60\times\vec{0} + 40\vec{r}_2}{100}$$

$$\Rightarrow \quad \vec{r}_2 = \frac{100}{40}(3\hat{i}+3\hat{j}+3\hat{k})$$

$$\Rightarrow \quad = 7.5\hat{i}+7.5\hat{j}+7.5\hat{k}$$



Ans(b)

Solution: 7

$m_1 = 10\,kg$; $\vec{r}_1 = \hat{i} + \hat{j} + \hat{k}$

$m_2 = 30\,kg$; $\vec{r}_2 = -\hat{i} - \hat{j} - \hat{k}$

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$

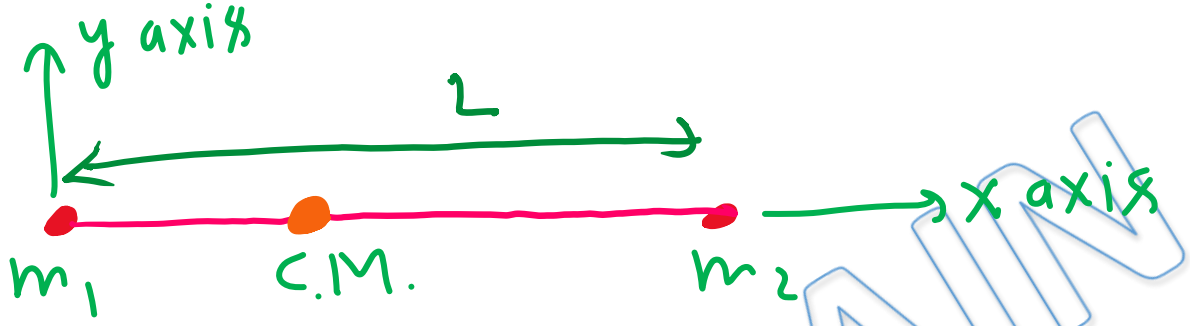
$$\vec{r}_{cm} = \frac{10(\hat{i}+\hat{j}+\hat{k}) + 30(-\hat{i}-\hat{j}-\hat{k})}{(10+30)}$$

$$\vec{r}_{cm} = \frac{-20(\hat{i}+\hat{j}+\hat{k})}{40}$$

$$\boxed{\vec{r}_{cm} = -\frac{(\hat{i}+\hat{j}+\hat{k})}{2}}$$ Ans.

Ans. a

Solution: 8



$$y_{CM} = \frac{m_1 \times 0 + m_2 \times 0}{m_1 + m_2} = 0$$

$\Rightarrow$ C.M. is at line joining m_1 and m_2.

Ans(d)

Solution: 9

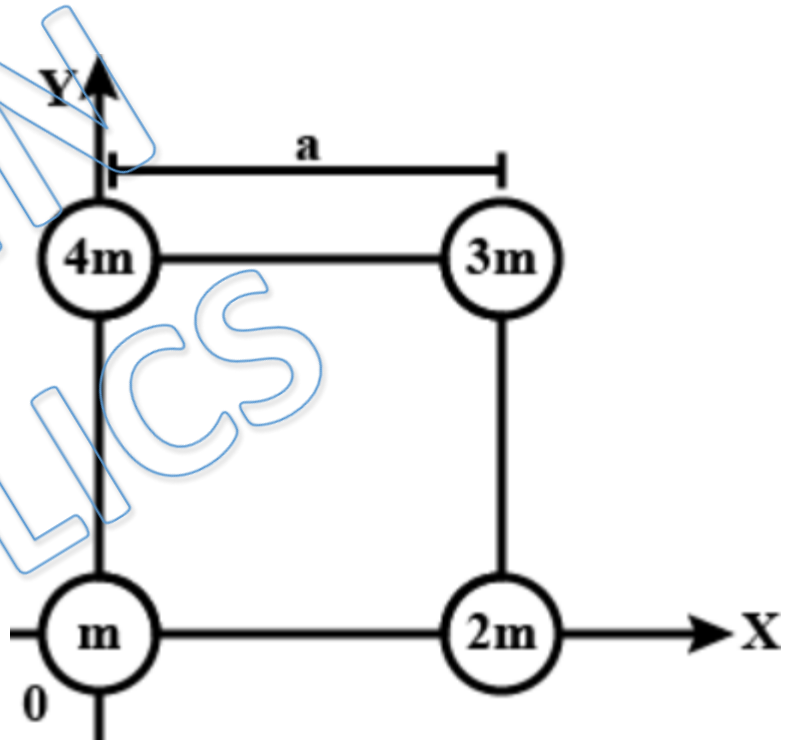
$$x_{cm} = \frac{(m+4m)\times 0 + (3m+2m)\times a}{m+2m+3m+4m}$$

$$\boxed{x_{cm} = \frac{a}{2}}$$

$$y_{cm} = \frac{(m+2m)\times 0 + (4m+3m)\times a}{10m}$$

$$\boxed{y_{cm} = \frac{7a}{10}}$$

$$\boxed{(x_{cm}, y_{cm}) \equiv \left(\frac{a}{2}, \frac{7a}{10}\right)}$$ Ans.



Ans. c

Solution: 10

$$x_A = \frac{(8+2)\times 0 + (4+2)\times a}{16} = \frac{3}{8}a$$

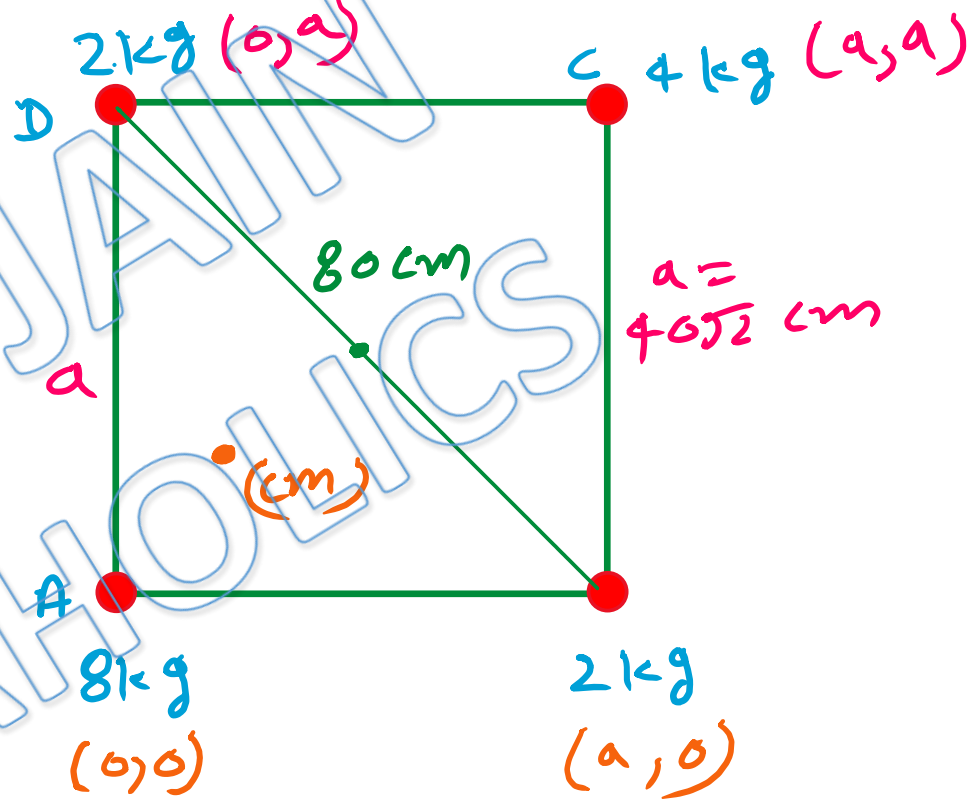
$$y_A = \frac{(8+2)\times 0 + (2+4)\times a}{16} = \frac{3}{8}a$$

$$d = \sqrt{x_A^2 + y_A^2}$$

$$d = \sqrt{\left(\frac{3}{8}a\right)^2 + \left(\frac{3}{8}a\right)^2} = \sqrt{2}\left(\frac{3}{8}a\right)$$

$$d = \sqrt{2} \times \frac{3}{8} \times 40\sqrt{2}$$

$$\boxed{d = 30\ \text{cm}}$$



Ans. b

Solution: 11

$6kg(0,0)$; $4kg(0,4)$; $5kg(3,0)$; $9kg(x,y)$

$$x_{cm} = \frac{(6\times0)+(4\times0)+(5\times3)+(9\times x)}{6+4+5+9} = 0$$

$$15+9x=0 \Rightarrow \boxed{x=-\frac{5}{3}}$$

$$y_{cm} = \frac{(6\times0)+(4\times4)+(5\times0)+(9\times y)}{6+4+5+9} = 0$$

$$16+9y=0 \Rightarrow \boxed{y=-\frac{16}{9}}$$

$$\boxed{(x,y) \equiv \left(-\frac{5}{3}, -\frac{16}{9}\right)m} \quad \text{Ans.}$$

Ans. c

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